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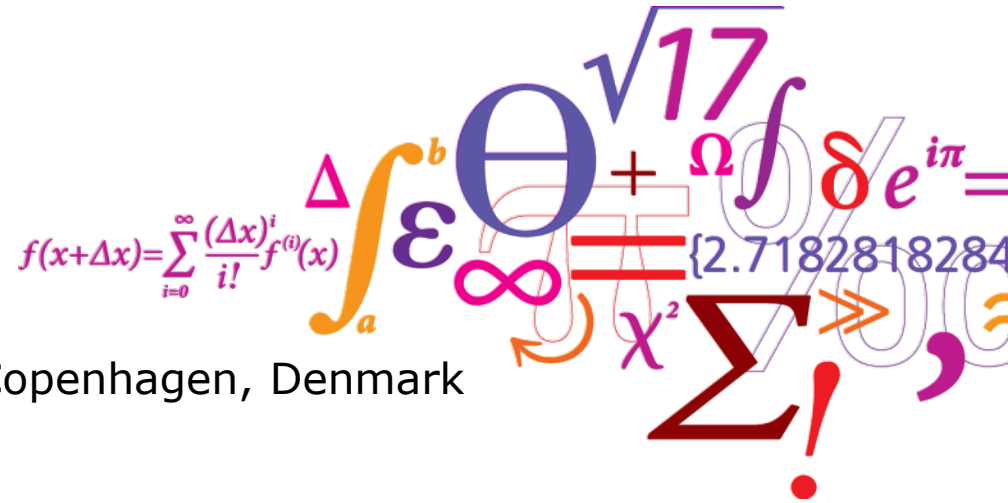

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DTU Management Engineering
Department of Management Engineering

Overview

- Electromobility+ EV-STEP
- Stepwise tutorial models in TIMES
- Technology model for electric vehicles
- Sifre. Model for operation of the Danish electricity system
- Users' profiles for electric vehicles
- Time slices in TIMES
- Parameters in aggregated models

Abstract

- The set of TIMES models for stepwise introduction of new features can be used both as tutorials and for analysis of integration of technologies into a region, where the structural data are described by the model. The current set of tutorials developed for ETSAP covers EU27 as the model region.
- We shall consider modelling of integration of electric vehicles into a region with many years of experience with a day-ahead wholesale spot market for electricity. The area prices for western Denmark have been increasingly influenced by wind power since 1999. The region also have strong connections to neighbouring electricity markets with available statistics for hourly prices and volumes, while internal transmission constraints are limited.
- We shall analyse the possible values of aggregated parameters for time-slices and structural constraints for a model of technology choice for transport for some 20 years ahead. The TIMES model will be run in parallel with test of a new model for operation of the electric system with combined heat and power and heat storages.

Sheet EnergyBalance in TIMES DEMO_EV

		COA	GAS	OIL	NUC	RNW	SLU	HET	ELC	
		Solid Fuels	Natural Gas	Crude Oil	Nuclear Energy	Renewable Energies	Industrial Wastes	Derived Heat	Electricity	Total
	PRIMARY									
MIN	Domestic Supply	8098	7899	5379	10775	5027	0	0	0	**37178**
IMP	Imports	6463	13292	39960	0	113	0	0	1168	**60995**
EXP	Exports	-1147	-2516	-14831	0	-72	0	0	-1127	**-19693**
TPS	Total Primary Supply	13414	18675	30508	10775	5067	0	0	41	**78480**
	CONVERSION									
ESC	Energy Sector Consumption	-58	-793	-1849	0	-4	-2	0	0	**-2705**
ELC	Electricity Plants	-9598	-5636	-1225	-10775	-1256	-33	1738	11581	**-15203**
HPL	Heat Plants	-161	-301	-50	0	-140	-2	659	0	**5**
REF	Petroleum Refineries			-31736						**-31736**
	Total Conversion	-9817	-6730	-34859	-10775	-1400	-36	2396	11581	**-49640**
	FINAL									
RSD	Residential	357	5160	2289	0	1294	0	865	2872	**12837**
COM	Commercial	57	1752	855	0	67	1	255	2527	**5514**
IND	Industry	1897	4437	2016	0	722	117	634	4088	**13911**
AGR	Agriculture	44	201	797	0	63	0	16	19	**1141**
TRA	Transport	1	21	14851	0	131	0	0	266	**15270**
OTH	Other	1189	0	393	0	1390	0	627	650	**4249**
NEN	Non Energy	52	634	4073		0	0	0	0	**4759**
BNK	Bunkers	0	0	2111		0	0	0	0	**2111**
TFC	Total Final Consumption	3597	12205	27385	0	3667	118	2396	10423	59791

Data used in the template to buld the model

Column B (rows 5 -24) is used to set up the technology and commoditiy names and descriptions in the model.

Row 2 and Row 5 are used to build techology and commodity names and descriptions in the model.

	COA	GAS	OIL
Domestic Supply Curve Share - Step 1	75%	50%	80%
Domestic Supply Curve Share - Step 2	25%	50%	20%

This share is used to split the total domestic production in more than one step. In this way it is possible to set up in the model a supply curve defined by the maximum production and cost

Sector	Break-out by end-use	Solid Fuels	Natural Gas	Crude oil	Nuclear Energy	Renewable Energies	Industrial Wastes	Derived Heat	Electricity	
RSD	SH									Space Heating
RSD	AP									Appliancens
RSD	OT		1							Other
COM	D1									Demand 1
COM	D6									Demand 6
TRA	D1			1						Demand 1
TRA	D2								1	Demand 2

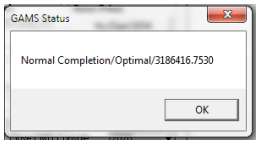
Emission by sector	CO2 Carbon dioxide	Nox NOX	VOC VOC
RSD	1		
TRA	1		
OTH	1		
ELC	1		

Added for EV version

Sheet RES&OBJ in TIMES DEMO_EV

Objective Function

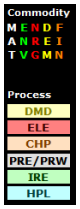
Run name: DemoS_004



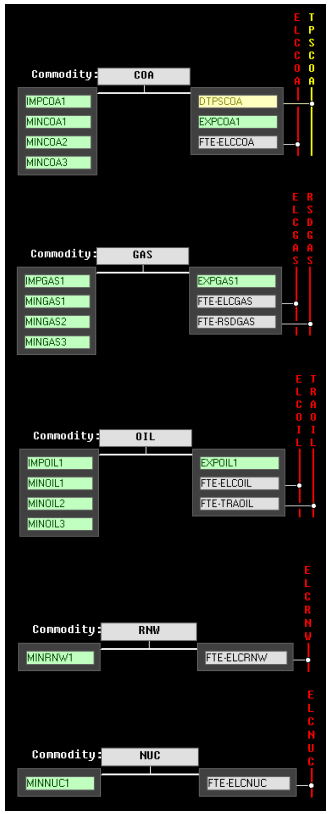
Objective Function by Scenario
_SysCost VEDA-BE table

Attribute	Region		
~Scenario~	REG1	Total	
DemoS_004	3,186,416.75	3,186,416.75	
DemoS_004a	3,188,469.26	3,188,469.26	
DemoS_004b	3,188,469.26	3,188,469.26	

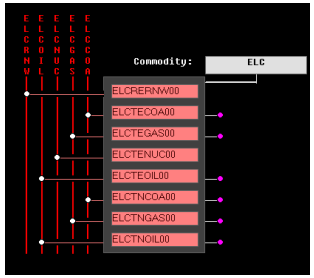
Reference Energy System (from VEDA-FE Go-To RES feature)



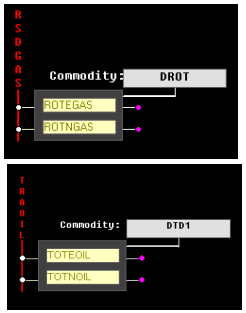
Primary Supply (Mining, Import/Export)



Conversion (Power Sector)



Demand Sectors



Sheet SectorFuels in TIMES DEMO_EV

Sector Name	Commodity	Description	Deafult unit	Currency	Existing
		Sector Fuel	PJ	M€2005	E

~FI_Comm

Csets	Region	CommName	CommDesc	Unit	LimType	CTSLvl	PeakTS	Ctype
*Commodity Set	Region				Sense of the			Electricity
Membership	Name	Commodity Name	Commodity Description	Unit	Balance EQN.	Timeslice Level	Peak Monitoring	Indicator
NRG		RSDGAS	Residential Natural Gas	PJ				
		TRAOIL	Transport Crude Oil	PJ				
		TRAELC	Transport Electricity	PJ		DAYNITE		
		TRAELCEV	Transport Electricity for EV cars	PJ				
		ELCCOA	Electricity Plants Solid Fuels	PJ				
		ELCGAS	Electricity Plants Natural Gas	PJ				
		ELCOIL	Electricity Plants Crude Oil	PJ				
		ELCRNW	Electricity Plants Renewable Energies	PJ				
		ELCNUC	Electricity Plants Nuclear Energy	PJ				

~FI_T

TechName	Comm-IN	Comm-OUT	STOCK	EFF	LIFE
		Output	Existing Installed		
*Technology Name	Input Commodity	Commodity	Capacity	Efficiency	Lifetime
*Units			PJa		Years
FTE-RSDGAS	GAS	RSDGAS		1.00	30
FTE-TRAOIL	OIL	TRAOIL		1.00	30
FTE-TRAELC	ELC	TRAELC	20	1.00	50
FTE-TRAELCEV	CEV	TRAELCEV		1.00	50
FTE-ELCCOA	COA	ELCCOA		1.00	30
FTE-ELCGAS	GAS	ELCGAS		1.00	30
FTE-ELCOIL	OIL	ELCOIL		1.00	30
FTE-ELCRNW	RNW	ELCRNW		1.00	30
FTE-ELCNUC	NUC	ELCNUC		1.00	30

~FI_Process

Sets	Region	TechName	TechDesc	Tact	Tcap	Tslvl	PrimaryCG	Vintage
*Process Set	Region			Activity		TimeSlice level of	Primary Commodity	Vintage
Membership	Name	Technology Name	Technology Description	Unit	Capacity Unit	Process Activity	Group	Tracking
*								
PRE		FTE-RSDGAS	Sector Fuel Existing Residential Sector- Natural Gas	PJ	PJa			
		FTE-TRAOIL	Sector Fuel Existing Transport Sector- Crude Oil	PJ	PJa			
		FTE-TRAELC	Sector Fuel Technology Existing Transport Electricity	PJ	PJa			
		FTE-TRAELCEV	Sector Fuel Technology Existing Transport Electricity for EV cars	PJ	PJa			
		FTE-ELCCOA	Sector Fuel Technology Existing Electricity Plants Solid Fuels	PJ	PJa			
		FTE-ELCGAS	Sector Fuel Technology Existing Electricity Plants Natural Gas	PJ	PJa			
		FTE-ELCOIL	Sector Fuel Technology Existing Electricity Plants Crude Oil	PJ	PJa			
		FTE-ELCRNW	Sector Fuel Technology Existing Electricity Plants Renewable Energies	PJ	PJa			
		FTE-ELCNUC	Sector Fuel Technology Existing Electricity Plants Nuclear Energy	PJ	PJa			

User inputs

Linked to the Energy Balance

Declare sectoral energy commodities (FI_COMM table) and define each ssectoral fuel technology option (FI_Process table).

Construct a fuel technology to convert the fuel commodity name from the supply sector to a sectoral specific fuel commodity (e.g. from GAS to RSDGAS)

Sheet DemSect_TRA in TIMES DEMO_EV

Sector Name	Description	Type	Default Unit	Secondary Unit	Currency Unit	Capacity	Existing	New
TRA	Transport	Technologies	PJ	Million_Pkm MVKms	M€2005	000_Units	E	N

Previous version c:\VEDA\VEDA_Models\DEMO_S004\VT_REG_PRI_V04.xls modified by Konstantinos Genikonsakis, DeustoTech, Bilbao, Spain, October 2013, Updated to current version by Poul Erik Grohnheit, DTU, April 2014

~FI_T

TechName	Comm-IN	Comm-OUT	STOCK	EFF	AFA	INVCOST	FIXOM	LIFE	START	ENV_ACT
*Technology Name	Input Commodity	Output Commodity	Existing Installed Capacity	Efficiency	Utilisation Factor	Invesctment Cost	Fixed O&M Cost	Lifetime		Activity Emission Coefficient
*Units			PJa			M€2005/PJ	M€2005/PJa	Years		kt
TOTEOIL	TRAOIL	DTD1	16666	1.00	0.90		0.20	10		
		TRACO2								65.0
TOTNOIL	TRAOIL	DTD1		1.10	0.90	10	0.20	15	2006	
		TRACO2								59.1

~FI_Comm

Csets	Region	CommName	CommDesc	Unit	LimType	CTSLvl	PeakTS	Ctype
*Commodity Set Membership	Region Name	Commodity Name	Commodity Description	Unit	Sense of the Balance EQN.	Timeslice Level	Peak Monitoring	Electricity Indicator
DEM		DTD1	Demand Transport Sector - Demand 1	PJ				
DEM		DTD2	Demand Transport Sector - Demand 2	Million_Pkm	DAYNITE			
ENV		TRACO2	Transport Carbon dioxide	kt				

~FI_Process

Sets	Region	TechName	TechDesc	Tact	Tcap	Tslvl	PrimaryCG	Vintage
*Process Set Membership	Region Name	Technology Name	Technology Description	Activity Unit	Capacity Unit	TimeSlice level of Process Activity	Primary Commodity Group	Vintage Tracking
DMD		TOTEOIL	Demand Technologies Transport Sector - Existing - Crude Oil	PJ	PJa			
		TOTNOIL	Demand Technologies Transport Sector - New - Crude Oil	PJ	PJa			
		TOTNOIL00	Demand Technologies Transport Sector - Existing - Crude Oil	MVKm	0			
		TOTNOIL00	Demand Technologies Transport Sector - New - Crude Oil	MVKm	0			
		TOTNELCV2Guse01	Demand Technologies Transport Sector - New - EV use Electricity	MVKm	0			
DMD,NST		TOTNV2Gstorage01	Demand Technologies Transport Sector - New - EV storage Electricity	PJ	PJa	DAYNITE		
		TOTNELC01	Demand Technologies Transport Sector - New Demand 2 - Electricity	MVKm	000_Units			
		TOTNELC	Demand Technologies Transport Sector - New Demand 1 - Electricity	PJ	PJa			

Declare demand car transport sector a demand commodity and transport carbon dioxide an environmental commodity (FI_COMM table) and define demand technology options (FI_Process table).

Construct demand technologies to deliver the transport car demand.

User inputs
Linked to the Energy Balance
Added for EV version

Proposed modelling of passenger cars

~FI_T

TechName	Comm-IN	Comm-OUT	STOCK	EFF	AFA	ACTFLO	Cap2Act	INVCOST	FIXOM	LIFE	START	ENV_ACT
*Technology Name	Input Commodity	Output Commodity	Existing Installed Capacity	Efficiency				Invesctment Cost	Fixed O&M Cost	Remaining Lifetime		Activity Emission Coefficient
*Units			0	/	Max Ann Km	Passenger/Car	stock/demand	M€2005/	a	Years		kt
TOTNOIL00	TRAOIL	DTD2	225654	412.82	15000	1.5	0.001	20	0.4	8		
		TRACO2										65
TOTNOIL00	TRAOIL	DTD2		433.47	15000	1.5	0.001	20	0.4	12	2006	
		TRACO2										65
TOTNELCV2Guse01	TRAELCEV	DTD2		1666.67	15000	1.5	0.001	23	0.46	15	2015	

V2G storage

~FI_T

TechName	Comm-IN	TimeSlice	Comm-OUT	STOCK	AFA	INVCOST	FIXOM	LIFE	START	ENV_ACT	NSTTS	STG_EFF	PEAK
*Technology Name	Input Commodity	TimeSlice(s)	Output Commodity	Existing Installed Capacity	Utilisation Factor	Invesctment Cost	Fixed O&M Cost	Remaining Lifetime		Activity Emission Coefficient	Charging TimeSlices	Storage Efficiency	
*Units				a		M€2005/PJ	M€2005/PJa	Years		kt			
TOTNV2Gstorage01	TRAELC		TRAELCEV					15	2015			0.98	1
		SN,WN	ELC								1		

Conversion factors

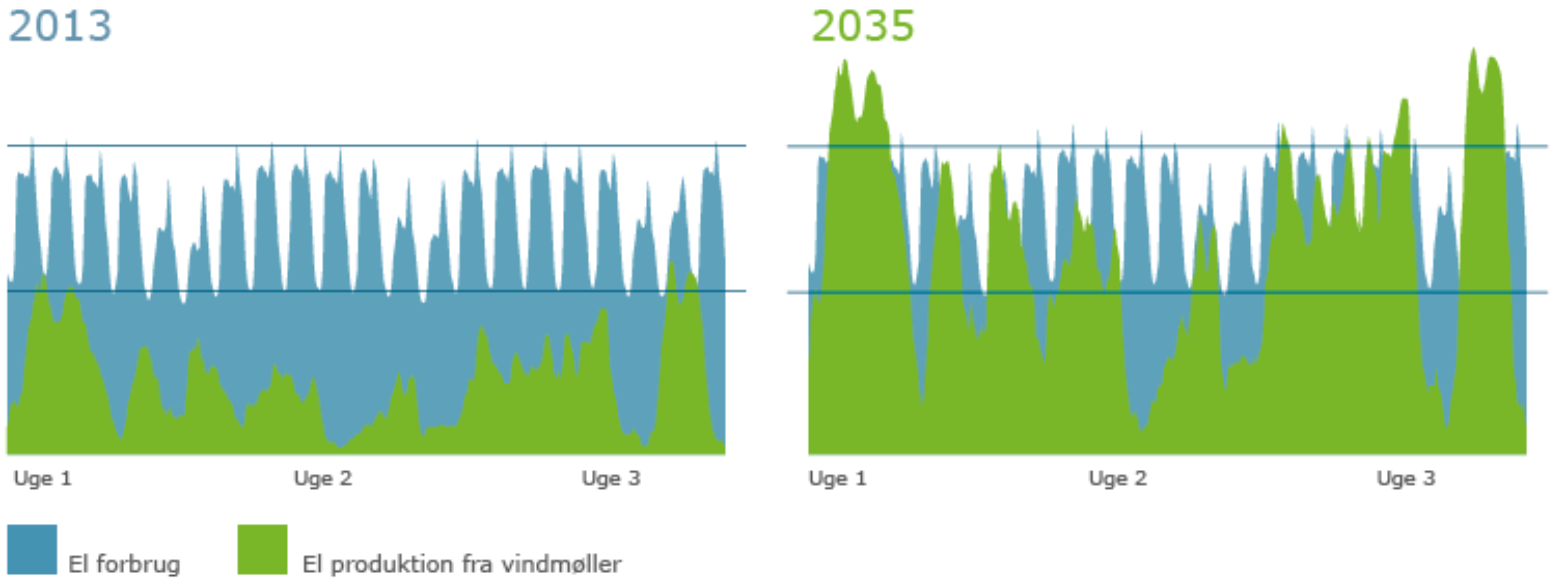
ktoe to PJ	0.041868	
	ktoe to Lt	PJ to Lt
TRADST	1123469	26833603
TRAGSL	1198179	28618008
TRALPG	1631858	38976268
TRAELC	11630000	277777778

Average Vehicle Efficiency per 100k

TRAOIL	6.5	Lt
TRAELC	16.7	kWh

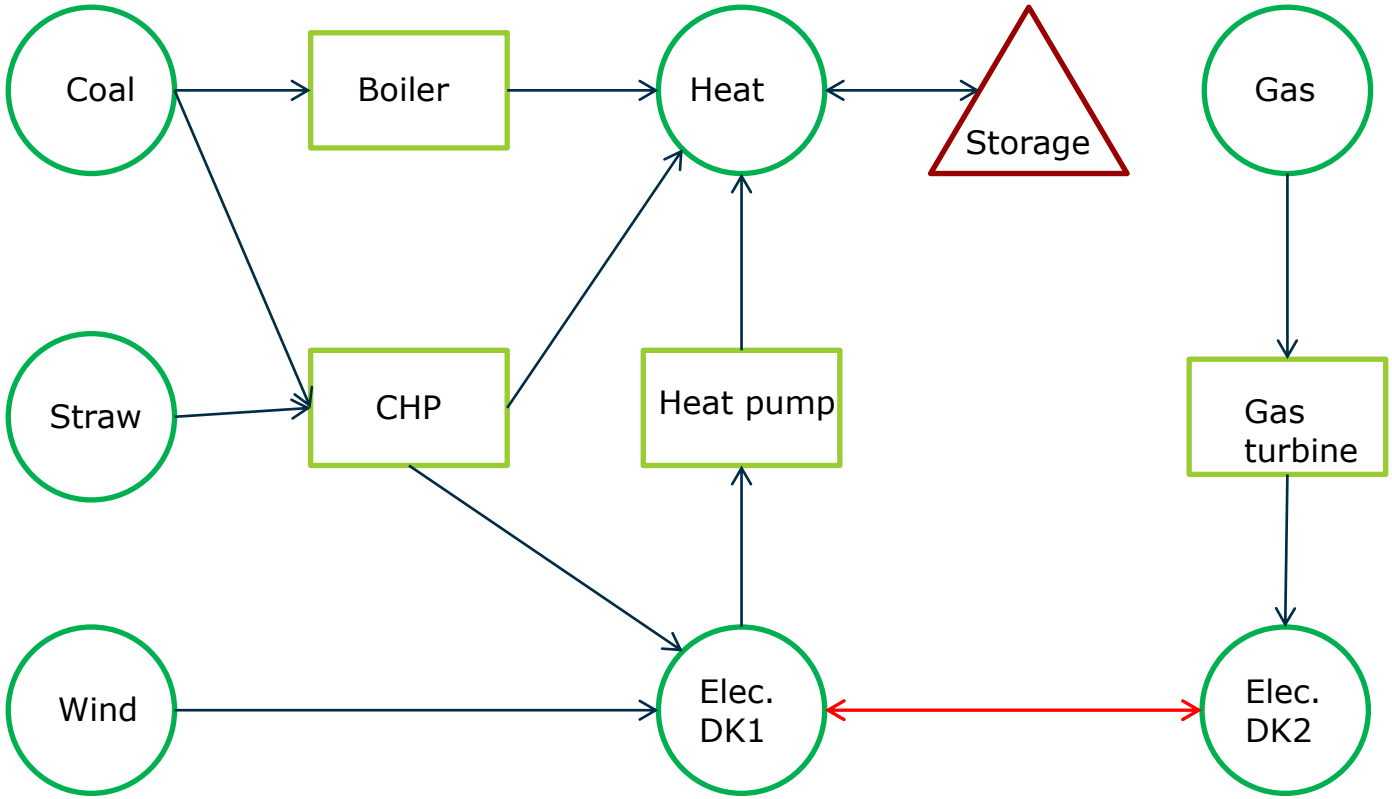
Challenges of more wind power

Wind power generation and consumption on different times



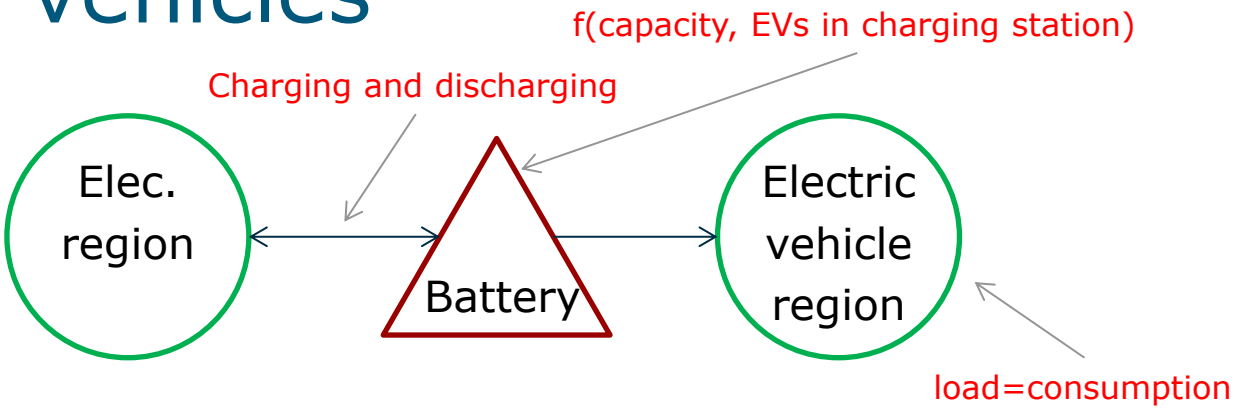
Translated from Sifre presentation Energinet.dk 27 August 2014

Example of an energy system in Sifre



Translated from Sifre presentation Energinet.dk 27 August 2014

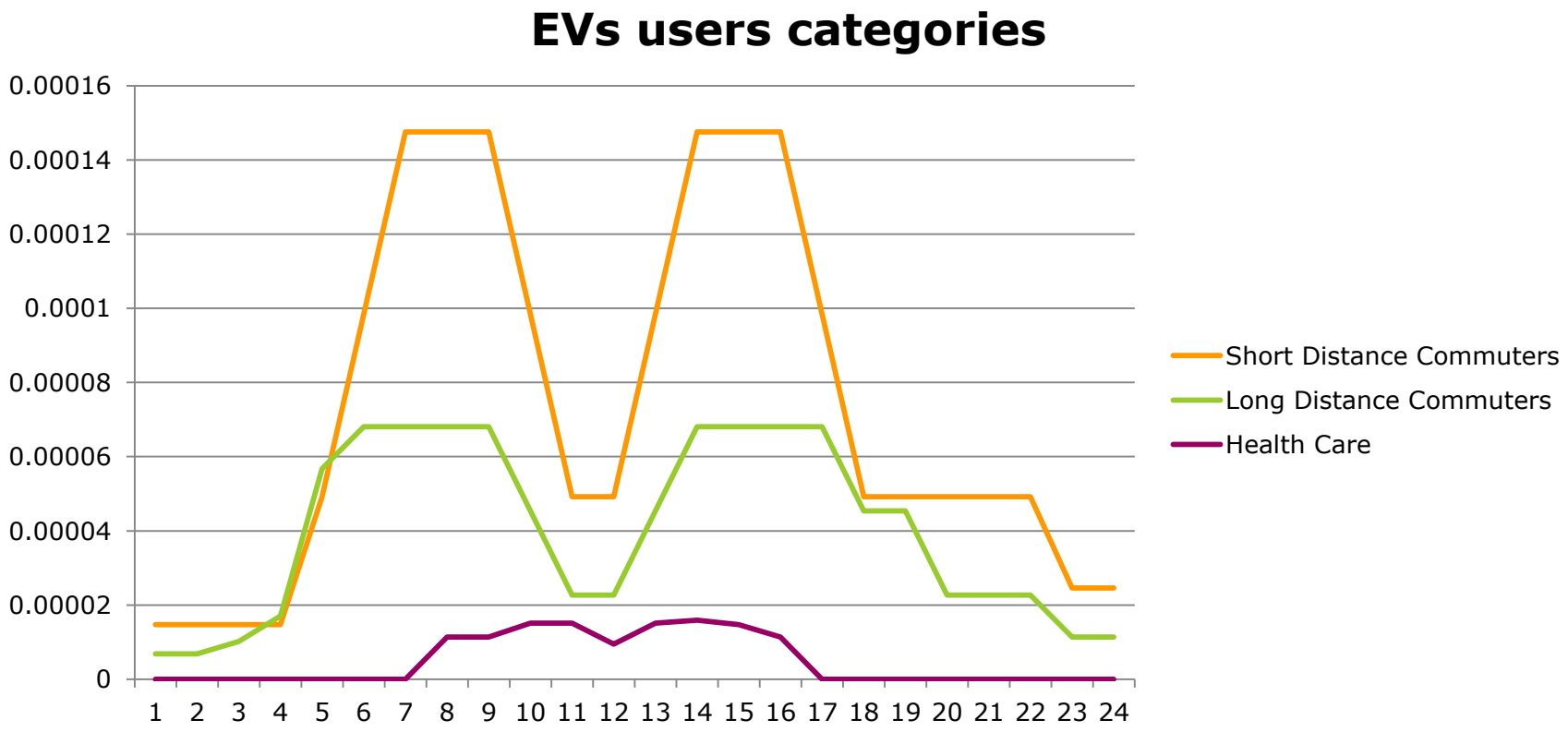
Electric vehicles



- Aggregated representation: Electric vehicle region is a large number of EVs
- Data requirements:
  - EV hourly electric consumption
  - Capacity of the aggregated EV battery
  - Charging and discharging rates
  - Relation between EV electric consumption and utilisation of EVs in charging station — Modeled by a reduced share of EVs in charging when EV consumption is high

Translated from Sifre presentation Energinet.dk 27 August 2014

EVs users profiles - qualitative description

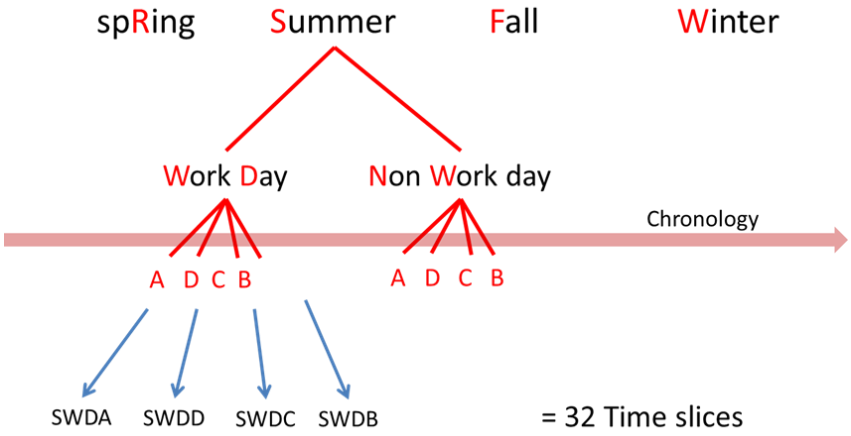


EVs users profiles - qualitative description

- Short distance commuters
  - Driving less than one hour to work
- Long distance commuters
  - Driving more than one hour to work
  - Produce thicker tails in the load curve
- Health Care Services
  - Drive mainly between 8 and 17 (working hours)
  - Moderate load decrease during lunch time
- Vehicle-to-grid
  - Short distance commuter seem the primary target
  - Only moderate availability for discharging should be expected from long distance commuters and health care services
  - Hybrid vehicles users could however be more available for discharging

Aggregation of parameters

- Operation model – Sifre or SIVAEL
  - Exogenous technology capacities
  - Chronological simulation of hours
- Optimisation model – TIMES or Balmorel
  - Technology choice as optimisation result
  - Time slices – aggregation of chronological data
- Macroeconomic model – IMACLIM or other CGE models
  - Single aggregated parameter for utilisation time for electric vehicles



Definition of time slices in TIMES-DK

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